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End-of-life management in new product development

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A B S T R A C T

Developing a sustainable and environmentally friendly product has become the primary concern in the car manufacturing industry. The new legislation “End of Life Vehicle” increased design complexities of car modules, subsystems, and components in a way that achieves the goals of reducing, reusing and recycling materials. The car bumper system is a complicated exterior module designed to prevent physical damage, reduce aerodynamic drag force, and be aesthetically pleasing to the consumer in addition to End of Life vehicle processing, which employs dismantling, shredding and landfilling. Design for dismantling is the first step in ELV’s implementation to optimize, the separating of the components and recycling of the materials of the bumper system. This study focused on the analysis of the ELV’s value in redesigned solutions of a new car bumper system in comparison to the current bumper one (case study). It provided a guideline to address the critical considerations in selecting materials, dismantling bumpers’ components and joining bracket to facilitate dismantling, separating, and recycling.

1. Introduction

Automotive production has increased from the last decade and made ELV’s a big challenge for the automotive industry. More than 1.2 billion cars registered in the world since 2015, and it is expected to have 2.8 billion vehicles on the planet in 2036 (Chesterton, 2018). The number of ELVs was about 40 million units/years in 2014 excluding Russia and will increased every year. In Canada, more than 1.2 million retired cars add to ELV processing every year (Canada, 2011). The automotive Recyclers of Canada reported that in Ontario, about 600,000 retired vehicles create more than 150,000 tones of vehicle waste that goes to landfill sites (Miller, 2011). ELV processing can be facilitated from the design stage, i.e. design for disassembly, recycling and remanufacturing, which can be applied in different modules, subsystem, and components (Tian & Chen, 2014). A bumper system is a complicated exterior component that should fulfil safety regulations by passing high impact, low impact, and pedestrian impact tests in addition to the environmental considerations (ELVs) from the design stage. The front bumper comprises three main components: fascia, an energy absorber and beam (Sapuan, Maleque, Hameedullah, Suddin, & Ismail, 2005). Most of the parts are made of polymers with different grades assembled to fulfil defined standards. This study focused on ELVs consideration in the product development phase of the front bumper system of a passenger car including selecting materials, dismantling parts, and joining components. Selecting the proper materials guides the designer to the suitable man- [illegible] the proper joining method between bumper components expedites the recycling process.

Manufacturing companies mostly emphasize the forward supply chain for maximizing their benefit and do not recognize the importance of reverse logistics after the product’s lifespan (Govindan, Palaniappan, Zhu, & Kannan, 2012). The increasing number of the reversed products have caused the firms to focus on the three Rs (Reducing, Reusing and Recycling), which must be considered from the product development phase (Azmi, Mat Saman, Sharif, Zakuan, & Mahmood, 2013).

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2. Literature Review

The bumper system is the primary structure, which protect cars from front and rear collisions (Liu, Lu, & Zhu, 2016). It must absorb the accidental kinetic energy by deflection in a low-speed impact, deformation in high- speed impact, and flexion in pedestrian impact tests. (Davoodi et al., 2012). In addition to the safety parameters, the non- structural components of the bumper system, fascia, should reduce the aerodynamic drag force while fulfilling the aesthetics features to enhance customer attraction. Although OEM and car manufacturers consistently work to develop a bumper system that meets all the desired specifications, it still needs to develop a prominent mechanical bumper system, which responds both ultimate flexibility and rigidity simultaneously to minimize the accidental damage. According to the Canadian Transportation Safety Board, 160,000 car accidents occur each year in Canada of which 2,800 to 2,900 result in deaths. The report states that 22.7 percent of all car accidents occurred because one car hit another car, 7.9 percent of the accidents were single-car accidents, 5.8 percent were triggered by acts of nature, 5.4 percent occurred because a car hit a parked car or a tree, and 0.4 percent occurred because the car hit a pedestrian (TSBC). The car bumper system is the first component involved in the accident in all the above accidental cases to protect the driver, passengers, and car body in a collision. Therefore, the high demand for car bumper repair and replacement led the OEM to concentrate on the facilitation of dismantling, disassembling, and by selecting the proper joining method of the bumper components together and to the car body to reduce the cost and time of separating and recycling.

2.1 Manufacturing Process

The manufacturing process of the bumper strictly depends on the selected materials and its affect on performance, so it must be set simultaneously for achieving the anticipated specification (Davoodi et al., 2012). Selected material of the bumper needs to pass the safety regulations with optimum weight — the conventional bumper system made of metallic materials, which neither had lightness nor had crashworthiness specifications. The polymer composite has replaced metal to increase both properties simultaneously. Renault produced a plastic bumper by sheet moulding compound "SMC" in 1971 with combinations of polycarbonate (PC), and Acrylonitrile butadiene styrene (ABS) called PC/ABS. It integrates the fibres (glass or carbon) with thermoset resin epoxy, vinyl ester, or polyester and compacts them to the desired thickness and stores them for several days for the final cure to use. Although SMC was the typical process for manufacturing the bumper components for many years, the material was not recyclable, and the process was time-consuming. Therefore, OEM used thermoplastic materials with an injection moulding process, which introduced shorter cycle time, higher quality, proper thickness, and recyclability. The designer determined the adequate thicknesses at different sections of the fascia, adds reinforced ribs and places the connector pins to enhance strength and accommodate the joining of the bumper components through an injection moulding process. The engineering team simultaneously has to consider manufacturing (DFM), assembling (DFA), disassembling (DFD) in addition to the 3R (Reducing, Reusing and Recycling) during the product development process. They need to focus on an effective dismantling and shredding process in ELV approach from the joining method to the material selection of different components

2.2 Bracket Joining Method

In the traditional design, the bumper is joined the body of the car through metal brackets. In fact, bracket is fixed to the fascia by melting and punching four embedded pins located on the inner surface of the bumper. The plastic pins are melted via a high-frequency ultrasonic welding process and connected the bracket to the fascia. One of the disadvantages of this method was that the bracket could not be removed from the fascia without cutting out whole pins after dismounting the bumper from the body in white. It was a difficult, unsafe, and challenging method for the three Rs consideration because the brackets must be extracted from the fascia before shredding. In the new design, the pins replaced the ribs to enhance the connected area. Moreover, the plastic brackets have replaced the metal brackets and the welded bolts on the metal bracket are substituted with the embedded inserted bolt to facilitate the bumper assembling. The ribs pass through the accommodated holes in the side-bracket, which provide more accurate positioning before joining. The ribs on the fascia are melted through ultrasound welding when a hatched the plastic bracket and fascia together. The new welding method remarkably reduces the bumper assembly time and increases the joining strength and process consistency in comparison to the mechanical joining method.

2.3 Material Selection

Selecting improper materials for bumper components may cause poor performance, frequent maintenance and unexpected failure. Therefore, they must be selected based on the preset mechanical and physical properties and desired characteristics defined on their PDS. Proper materials should be light, cost-competitive, accessible, producible, recyclable, and preferably biodegradable (Davoodi et al., 2012). The structural components such as a bumper beam and absorbers should maintain impact stability by deflecting in low impact and deformation resistance by crushing in high impact in addition to the corrosion and heat resistance according to the test plan. The material of the side brackets of the bumper, which fix the fascia to the body in white (BIW), needs to be carefully selected to facilitate the recycling.

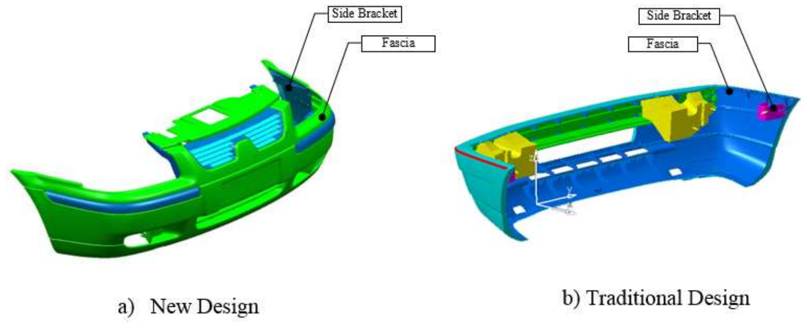

Fig. 1. Bumper side brackets

In the traditional design, the brackets are made from steel and joined to the fascia by melting of four plastic pins through the ultrasonic welding process (Fig 1). In addition to the resonances interface that occurred in metal, which causes a disturbing noise during the bracket welding process, the weight of the metal bracket and disassembling and separating of it from the plastic fascia was a significant issue after dismounting the bumper. In the new design, it is attempted to use uniform materials and a process that offer, the desired properties for both the fascia and bracket. Therefore, both are selected from the same polypropylene family with similar properties. It enhanced the welding strength and speed of the welding without suffering the resonance confusion. Moreover, it facilitates the recycling process by shredding the welded brackets and fascia without separating because they are not connected with metal clips or any other dissimilar materials.

2.4 Bumper Dismantling

The bumper product developer targeted the convenient dismantling in their new design to facilitate the reuse, recycling, and recovery of bumper components. In the traditional design, the bumper is fixed to the body in white (BIW) by the screws. The screws pass through the welded bolt on the bracket to adjust and fix the sides of the bumper to the body. Therefore, mounting the bumper needs an extra caution to align the screws to the welded bolt on the steel brackets. In the new design, a bolt inserted to an extra slide bracket, which is fitted to the main bracket. The sliding side bracket adjusts and aligns the position of the inserted bolt to its suitable position on the body to assist the assembly process. Moreover, in disassembling, the sliding bracket remains on the BIW while the main bracket dismounts from the BIW and then disassembles the bolt for recycling (Fig. 2).

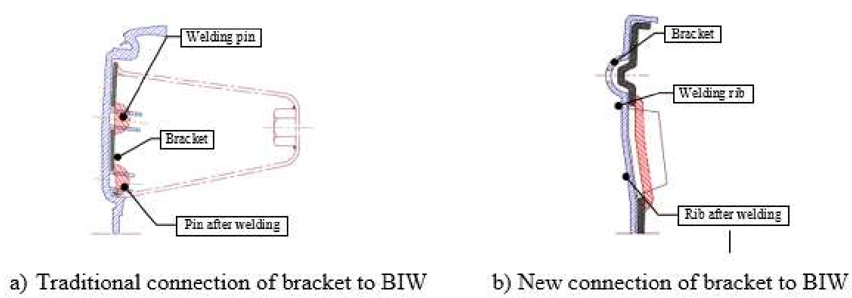

Fig. 2. Connection of bracket to body

3. Results and Discussions

The study focused on reverse logistics by concentrating on the Three Rs “Reducing, Reusing and Recycling” and comparing the three essential issues with traditional and new bumper design including “material selection, dismantling and the joining method” to expedite the recycling process. Moreover, it reviewed how these parameters affected every process. It is considered in new product development, which with traditional and new developed bumper system. It focused on selecting materials, dismantling bumper and joining components in the product development stage to facilitate the 3Rs.

It concluded that selecting the homogeneous materials for the fascia, bracket, and the bumper strip eliminates the disassembling process and the recycling. Therefore, the designer needs to strengthen the desired mechanical requirements of the brackets by adding the ribs instead of the metal brackets. Besides, the designer should employ the proper joining method for the bumper’s parts by melting the ribs fixing the fascia and bracket instead of using the external metal clips, which do not provide sufficient stability and reliability. Moreover, dismounting the bumper from the body could be facilitated by using the slide brackets instead of fixing it to the body by screws.

References

Azmi, M., Mat Saman, M. Z., Sharif, S., Zakuan, N., & Mahmood, S. (2013). Proposed framework for end-of-life vehicle recycling system implementation in Malaysia. *10.14279/depositonce-3753*.

Canada, A. R. O. (2011). *A National Approach to the Environmental Management of End-of-life Vehicles in Canada*.

Chesterton, A.. (2018). How many cars are there in the world? https://www.carsguide.com.au/car-advice/how-many-cars-are-there-in-the-world-70629

Davoodi, M., Sapuan, S., Aidy, A., Osman, N. A., Oshkour, A., & Abas, W. W. (2012). Development process of new bumper beam for passenger car: A review. *Materials & Design, 40*, 304-313.

Govindan, K., Palaniappan, M., Zhu, Q., & Kannan, D. (2012). Analysis of third party reverse logistics provider using interpretive structural modeling. *International Journal of Production Economics, 140*(1), 204-211.

Liu, Z., Lu, J., & Zhu, P. (2016). Lightweight design of automotive comp`osite bumper system using modified particle swarm optimizer. *Composite Structures, 140*, 630-643.

Miller, S. (2011). *Improving the Management of End-of-life Vehicles in Canada*.

Sapuan, S., Maleque, M., Hameedullah, M., Suddin, M., & Ismail, N. (2005). A note on the conceptual design of polymeric composite automotive bumper system. *Journal of materials processing technology, 159*(2), 145-151.

Tian, J., & Chen, M. (2014). Sustainable design for automotive products: Dismantling and recycling of end-of-life vehicles. *Waste management, 34*(2), 458-467. doi:10.1016/j.wasman.2013.11.005

TSBC. *Car accident facts and figures in Canada*. Retrieved from https://www.waterdowncollision.com/blog/auto-repair/interesting-accident-statistics/